# Sonification, Remote Sensing and Research & Education Networks in Sport Science and Rehabilitation

Dr Domenico Vicinanza
GEANT and Anglia Ruskin University, Cambridge, UK

Dr Genevieve K.R. Williams
Anglia Ruskin University, Cambridge, UK

**Keywords**: sport science, sonification, movement analysis, coordination, biomechanical modelling, rehabilitation

**Abstract:**

Remote sensors and Wireless Sensor Networks (WSN) are increasingly being applied to retrieve data from environmental measurements to motion and position tracking. Remote sensing provides the potential to collect data at spatial and temporal scales that could be either not feasible or difficult to implement with existing instrumentation. While remote sensing and wireless sensing is currently accepted as an adequate mechanism to gather remote data and share it over networks, very little has been currently done in the actual deployment of networked sensor-based infrastructures for sport and rehabilitation applications.

Data sonification is the use of audio signals to convey information or perceptualise data. Auditory perception of complex, structured information could have several advantages in terms of temporal, amplitude, and frequency resolution when compared to visual representations and often opens up possibilities for an alternative or complement to visualisation techniques. These advantages include the capability of the human ear to detect patterns, recognise timbres and follow different strands at the same time. This would offer, in a natural way, the opportunity of rendering different, interdependent variables into sound in such a way that a listener could gain relevant insight into the represented information or data.

Technology is rapidly changing they way athletes and sport coaches are working together. Accurate feedback, appropriate training, objective and reliable assessment techniques are the main ingredients to maintain and improve performances or to effectively recover from sport injuries.
In this study we investigate ways in which remote sensing and data sonification can improve standard data analysis techniques currently employed in some aspects of biomedical science with special reference to sport science and rehabilitation. Accelerometers, gyroscopes and advanced motion tracking devices have been widely used in biomechanics and motor control to measure kinematic and kinetic variables, verify functional models and to analyse macro-structures like posture, gait, joint dynamics and couplings.

Wireless accelerometers and gyroscopes are now particularly small (Figure 1) and inexpensive making them ideal for portable and mobile measurement devices.

Figure 1. Wireless Accelerometer (source: http://www.oemsensors.com/)

In the sport and rehabilitation context, we have performed several novel investigations using data sonification and advanced networking as support tools for accurate classification and diagnosis from working on audification of biomechanical data to converting spectra to tones, including real-time screening and feedback on signals. Sonification can provide a powerful magnifying glass in time-series analysis, perceiving short and long-range correlations in the measurements in a natural way (they appear as tones or spectral lines), listening to the effect of mechanical coupling, or studying the dynamical evolution of a system through changes in sonograms and spectra. As an example, Figure 2 displays a sonogram of a series of steps recorded by an accelerometer attached to the heel of a patient. It is easily noticeable how more accurate and granular is the spectral analysis, the amount of fine-grained information that is possible to retrieve from the sonogram (upper part) compared to the simple waveform analysis (lower part of the diagram). Even very small anomalies and tiny oscillations almost invisible in the lower part as wave signals are captured in the sonogram and decomposed in their spectral constituents, making the movement analysis more accurate.

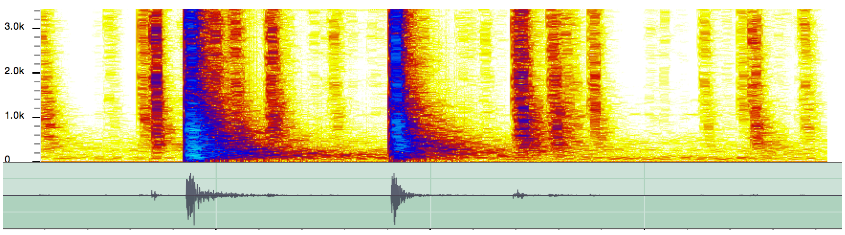


Figure 2. The sonic footprint (sonogram) of a series of steps recorded with an accelerometer located at the heel.

When coupled with remote sensing and networks, sonification can provide physicians, physiotherapists and sport patients with uniquely effective ways to analyse data and provide accurate and personalised feedback without having to travel to a particular hospital. Consultants can analyse sonograms generated by the sonification of sensors in real-time from anywhere in the world and give immediate and accurate feedback. Low-latency, extremely

high availability and a global footprint are crucial to make this possible; Research and Education Networks (RENs) can then play a unique enabler role here thanks to the high-quality of the connection, the extended reach to university hospitals and research centres and the availability of roaming services like eduroam and eduGAIN.
At the time of writing, networked audio facilities are planned at Anglia Ruskin University to retrieve through Research end Education networks (JISC, GEANT and sister networks) biomechanical data for world-wide real-time sonification for the first time.

Remote access to data and measurements are especially relevant when dealing with rehabilitation. While working with injured patients, having the possibility of thoroughly assessing the progress of a certain therapy, measuring in a quantitative way the success of a surgery can have a huge impact on the patience prognosis. Data sonification can display extremely accurately the progress of recovery in terms of subtle changes in spectral lines of kinematic/kinetic sensor audification.

**Bio**

Dr Domenico Vicinanza is a product manager for GÉANT and a Senior Lecturer at the Anglia Ruskin University in Cambridge, where he also leads the Sound And Game Engineering (SAGE) research group. He received his PhD in physics working at the European Laboratory for Particle Physics (CERN, Geneva) and he is a professional music composer and orchestrator. He worked for seven years as a Research Associate at University of Salerno and Roma Tre and as a Scientific Associate at CERN. His activities during this time included LHC Computing Grid sites administration, research and development for particle physics detectors, network monitoring and lecturing. He has an active collaboration with CERN, which commissioned an orchestral piece on scientific data, for their 60th anniversary and with NASA, writing music from data collected by the Voyager 1 and 2 space probes.
His research interests are on the applications of scientific data sonification in physics, neurobiology, motor control and biomechanics with colleague Dr Genevieve Williams.

Dr Genevieve Williams is a Senior Lecturer in Sports Biomechanics at Anglia Ruskin University. Genevieve gained her PhD in Biomechanics and Motor Control from Cardiff Metropolitan University under Professors Irwin, Kerwin and Newell. Her first post-doctoral position was at the University of Massachusetts in the Department of Kinesiology, where she worked with Professors Hamill and van Emmerik on how the coordination of whole body movement skills changes during learning. She then worked at The Penn State University in Professor K. M. Newell's lab, further exploring methods of quantifying coordination of whole body motor skills, and later in Professor Neely's Motor Control, Cognition and Neuroimaging laboratory at The Penn State.
Dr Williams' interests are in understanding movements from a Dynamical Systems theory perspective. She is currently working on projects for health research including ADHD, knee health, healthy gait, and on analysis of data using sonification with colleague Dr Domenico Vicinanza.